STS Education: A Rose by Any Other Name

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A chapter in:

A Vision for Science Education: Responding to the Work of Peter J. Fensham

Edited by Roger Cross

Published by Routledge Press, 2003

Peter Fensham's life work in science education has embraced diverse complexities that define science education in schools. These complexities were addressed in Fensham's (1988b) edited volume *Developments and Dilemmas in Science Education.* In its last two chapters, Joan Solomon (1988) and Harrie Eijkelhof and Koos Kortland (1988) described a promising movement whose slogan "science-technology-society" (STS) rallied together an assortment of innovative science and technology educators. At the time, STS science education confronted competing views on such issues as: the purpose of schools; the politics of a curriculum; the nature of the science curriculum, instruction, and assessment; the role of teachers; the nature of learning; the diversity of learners; and what "science" means. STS was a radical departure from the status quo because it required holistic changes to science education.

Peter Fensham contributed to the emergence and evolution of STS, and he continues to participate in its current transformation into "science for public understanding" and/or "citizen science." Fensham (1988c) recognized that curriculum change occurs within, and responds to, changes in social realities. For STS, these realities included (Fensham, 1983, 1988a, 1992; 1996b): World War II, the Pugwash movement toward science for social responsibility, the environmental movement, the women's movement, the post-Sputnik science curriculum reforms, the 1970's critical reaction to that reform movement, research into science instruction and student learning, decreasing enrolment in physical science, and a nagging persistence by a minority of science educators to present school science in a humanistic way (rather than the elitist pre-professional training through a "pipeline").

STS science required fundamental changes to the status quo of science education (Gaskell, 1982). In North America, Paul Hurd (1986) historically assessed several major attempts over the past century to change the status quo by humanising the science curriculum so it had relevance for a majority of students. All attempts at reform failed to achieve their original goals. In the 1980's, however, Fensham among others believed that social conditions had changed sufficiently to support a fundamental change to the science curriculum.

My chapter reviews, from a slightly Canadian perspective, how science educators settled on the slogan science-technology-society (STS) in the first place, how the field matured over the past two decades, and how the slogan will continue to change as new social and political realities challenge science educators. Deep philosophical tensions within schools themselves offer an insight into what seems to hold this community of science educators together.

The Emergence of STS in School Science

It was a historical coincidence in the late 1970's and early 80's that the phrase "science-technology-society" was current in a number of venues, while at the same time, a broad consensus among science educators was beginning to form around an innovation for science education. Many new and diverse proposals for school science were being advanced at the time: a reassessment of Western culture and the subsequent role of school science in the transformation of Western culture, an emerging need for political education for action, a call for interdisciplinary approaches to science education organized around broad problems, and a new type of demand for vocational and technocratic preparation (Fensham, 1992, 1996b; Solomon, 1988, 1994, this volume). All proposals seriously challenged the status quo.

As early as 1971 in the journal *Science Education*, Jim Gallagher proposed a new goal for school science:

> For future citizens in a democratic society, understanding the interrelationships of science, technology and society may be as important as understanding the concepts and processes of science. (p. 337)

His blueprint presciently mapped out a rationale for teaching scientific concepts and processes embedded in relevant technology and social issues, including the sociology of science itself. Gallagher's early publication was overshadowed by Paul Hurd's seminal 1975 article entitled "Science, Technology, and Society: New Goals for Interdisciplinary Science Teaching," which delineated a curriculum structure for STS science. Support for this new goal came in 1977 from Project Synthesis (Harms & Yager, 1981), a Tylerian study into the state of science education in the USA. Project Synthesis organized science education into five domains, one entitled "The Interaction of Science, Technology and Society (S/T/S)," headed by Joe Piel (1981), an engineer turned educator.

Piel's work was cited in a paper by Derek Holford (1982) entitled "Training Teachers for 'Science-Technology-Society' Roles," presented at the second IOSTE (International Organization for Science and Technology Education) Symposium in Nottingham, UK. The abbreviation "STS" was used by Holford, perhaps influenced by a book by John Ziman (1980), described below. Another IOSTE paper by Bill Hall (1982) discussed the challenges of "S/T/S" programs in schools. It referenced Ziman (1980) and Hurd (1975). Hall's ideas were also influenced by Rip's 1979 article about higher education programs, "The Social Context of

'Science, Technology and Society' Courses," which in turn drew upon the book by Spiegal-Rosing & Price (1977), *Science, Technology and Society: A Cross-Disciplinary Perspective,* a book influential in university circles at the time. Spiegal-Rosing and Price's book is credited with popularising the STS slogan in higher education (Solomon, 1988).

University STS programs in the USA had been formally initiated in 1969 at Cornell University and Pennsylvania State University (Cutcliffe, 1989). Their central focus was "the analysis and explication of science and technology as complex 'social constructs' entailing cultural, political, economic, and general theoretical questions" (Cutcliffe, 1996, p. 291). This content is generally more abstract than the STS content applicable to school science. Cutcliffe pointed out that the establishment of professional societies, journals, and newsletters in the 1970's gave STS a permanent home in higher education. This certainly influenced science educators who came into contact with its literature, particularly Piel's (1981) S/T/S group.

By 1982, however, international science educators had not reached consensus on a name for their new movement. Papers presented at the 1982 IOSTE Symposium reflected a preoccupation with a diversity of viewpoints: "science and/in society," "science and technology," "the interaction of science & technology with society & culture," along with Holford's "STS" and Hall's "S/T/S," mentioned above. The symposium fortuitously brought together reform-minded science educators from Australia, Canada, Italy, Netherlands, and UK who in various ways were developing (or had developed) new science curricula influenced by various proposals to change the status quo in science education. (See Fensham [1992, 1996d] and Solomon [1988, 1994, 1996] for a review of these curricula.) At an informal gathering within the symposium, several attendees agreed to initiate a special interest group within IOSTE under the banner "STS."

Probably the strongest influence on the group's choice of "science-technology-society" (STS) came from John Ziman's (1980) seminal work, *Teaching and Learning about Science and Society*. In spite of its title, the book consistently referred to "STS" in its articulation of the rationale, directions, and challenges for STS in school science. The book quickly became required reading for STS science educators everywhere. Although Bob Yager (1996a, p. 5) claimed that Ziman coined the term STS, the term was recognized in the UK by the STSA (Science Technology and Society Association) which existed under the auspices of the Council for Science and Society, of which Ziman was chairman.

In the fall of 1982 at an international science teachers' conference in Saskatoon, Canada, people from the IOSTE special interest group attempted to join forces with the USA group (Joe Piel, Bob Yager, and Rodger Bybee). An invisible college was formally established in Saskatoon and named the "STS Research Network." It was an international group of mainly university science educators and it published regular newsletters called *Missives* throughout the 1980's (Fensham, 1992). The USA delegates at the Saskatoon meeting continued independently of the invisible college to develop their own versions of STS science within: the NSTA (Bybee, 1985), the University of Iowa (Blunck &Yager, 1996), the environmental movement (Rubba & Wiesenmayer, 1985), and the "Science Through STS" project (Roy, 1984).

Over the years IOSTE continued to be an effective international venue for advancing STS science education worldwide. IOSTE Symposia featured STS strands that gave impetus to the growth of this new field.

Other influences on STS school educators in 1982 came from a number of other sources, including:

- higher education projects and programs, such as: "Science in a Social Context," SISCON (in the UK), the Deakin University course "Knowledge and Power" (Australia), the "Science & Society" units in an Open University science course (UK), and Schroeer's (1972) *Physics and Its Fifth Dimension: Society*.
- school projects, such as the Schools Council Integrated Science Project, *Patterns,* in the UK (Hall, 1973), *Science: A Way of Knowing* in Canada (Aikenhead & Fleming, 1975), *Science in Society* in the UK (Lewis, 1981), the PLON project in the Netherlands (Eijkelhof & Kortland, 1982), and *SISCON-in-Schools* in the UK (Solomon, 1983, this volume).
- journals, such as the *Bulletin of Science, Technology & Society* inaugurated in 1981, and *Science, Technology and Human Values* (originally a newsletter).
- publications, such as Jim Gaskell's (1982) insightful analysis "Science Education for Citizens," the NSTA's (1982) position statement *Science-Technology-Society: Science Education for the 1980s*, Glen Aikenhead's (1980) position piece *Science In Social Issues: Implications for Teaching*, Graham Orpwood and Doug Roberts' (1980) key article "Science and Society: Dimensions of Science Education for the '80s," Fletcher Watson's (1979) keynote address at the first IOSTE Symposium, and the ASE's (Association for Science Education) (1979) position statement *Alternatives for Science Education*.

- centres of humanistic approaches to science education in North America, principally at Harvard University (e.g. Klopfer & Cooley, 1963), Stanford University (e.g. Hurd, 1970), the Ontario Institute for Studies in Education (e.g. Roberts & Orpwood, 1979), University of Iowa (e.g. Yager, 1996a), and Berkeley University (e.g. Thier and Nagle, 1994).
- a 1977 initiative by American social studies professionals "to help teachers, students, and others deal effectively with science-related social issues" (McConnell, 1982, p. 10), a movement they called "science/technology/society."

It seems clear that the slogan STS came from different sources for different people influenced by different circumstances and embraced for different purposes. For almost every writer there will be a different citation for the original source of STS. More importantly, however, the slogan created networks of science educators dedicated to changing the status quo of school science (Durbin, 1991; Ziman, 1994).

The Evolution of STS

Peter Fensham (1985, 1988c, 1996a) contributed directly to the evolution of STS by forging links between science education and technology education, embedded in social contexts relevant *for all students*. The role of technology in STS programs has been an on-going concern (Cheek, 2000; Fensham 1988a; Layton, 1994). It is interesting to look back to 1982 and acknowledge that most educators who had been socialized into academic science were not comfortable with the inclusion of technology in STS (the science-and-society crowd, myself included). This explains their initial reticence to embrace the slogan STS. Their narrow view of technology as "applied science" needed to be confronted and re-conceptualised into a more authentic view (Fensham & Gardner, 1994). I recall Geoffrey Harrison's (1979) challenge to my own narrow thinking on technology at the first IOSTE Symposium. Thus, one theme in the evolution of STS has been the degree and sophistication to which technology is featured in an STS program.

Another theme to emerge from the evolution of STS is the complexity to which STS programs embrace the social context of science. Interestingly in Fensham's early writings, STS was characterised by a one-way influence of science/technology "on society;" while in his 1990 writings, a two-way mutual interaction was expressed. His apparent re-conceptualisation of the interaction mirrors a similar development for many colleagues who were originally schooled in the sciences with their science-centric view of the world. From project to project and from country to country, the scope of the social context of science in STS materials has sometimes been limited (for many reasons). For instance, some STS projects focussed on science-related issues in society but left unchallenged the out-of-date positivistic notions of science found in many science curricula (Bingle & Gaskell, 1994). A more comprehensive treatment of STS includes the *internal* social context (the epistemology, sociology, and history of science itself) as well as the *external* social context of science (Ziman, 1984). Again I recall my early biases favouring the epistemology of science. I thank Jim Gaskell (1982) among others for advancing more sophisticated ideas about the external social context of science.

The maturation of STS can also be traced by the developments in the assessment of student learning STS content: from a quantitative paradigm (Aikenhead, 1973), to a qualitative paradigm (Aikenhead, 1979, 1988; Aikenhead & Ryan, 1992; Driver, Leach, Millar & Scott, 1996), to a situated cognition paradigm (Gaskell, 1994; Solomon, 1992; Welzel & Roth, 1998).

The evolution of STS within school science is a complex story of the professional and intellectual development of individual science educators. Each country has its own story to tell. For instance in Canada and Israel, the environment was emphasised by adding an “E” to STS, producing STSE and STES respectively, with numerous school implementations achieved (Aikenhead, 2000; Zoller, 1991). In the Netherlands, the PLON project grew by embracing environmental education, while at the same time, moving into the secondary schools and continuing the project’s tradition of in-depth research studies with participating students (Eijkelhof, Kortland, & Lijnse, 1996). Some of these PLON units directly influenced the development of similar STS modules in Australia and Canada. In the UK, a variety of state-of-the-art projects and syllabi were developed (Solomon, 1996, this volume). These inspired and guided science educators worldwide. In Australia, a link to industrial technology became evident in some projects, in addition to the more conventional STS courses (Fensham & Corrigan, 1994; Giddings, 1996). In Belgium under the guidance of Gérard Fourez, ethics was added to STS, which named the journal *Sciences Technologies Ethique Societé*, published out of the University of Namur. In Italy, STS developed towards a more scientific discipline oriented approach to society issues (Prat, 1990). In Spain, Maria Manassero-Mas, Ángel Vázquez-Alonso and José Acevedo-Díaz’s (2001) have approached STS from an evaluative perspective, described in their book *Avaluació dels Temes de Ciència, Tecnologia i Societat*. The story from Japan involves science educators being influenced by projects in the UK and USA, but developing their own version of STS, along with considerable research (Nagasu & Kumano, 1996).

At various times, yearbooks and special issues of journals have focussed on STS science education and have advanced our collective thinking. Examples are found in Table 1. In-depth discussions of STS science are also located in key education books, listed in Table 2. The full story about the emergence and evolution of STS is found by reading all of these publications.

Tables 1 and 2 fit here.

STS for schools in the USA in the mid 1980's was greatly influenced by Rustum Roy's (2000) "Science Through STS" project, centred at Pennsylvania State University. In the 1970's, he had been on the editorial board of the British "Science in a Social Context" (SISCON) project. In 1988 in the USA, Roy founded the National Association for Science Technology Society (NASTS), which continues to meet annually and to produce a newsletter. These national meetings are a forum for multi-disciplinary sessions, bringing together school educators, industrialists, ethicists, engineers, social activists, and professors of STS programs in higher education. NASTS was the nexus of STS development in North America for science educators.

Unfortunately two major American science education initiatives, *Project 2061* (AAAS, 1989) and *Standards* (NRC, 1996), have completely dominated the science curriculum agenda in the USA. There is little but lip service paid to STS perspectives in these reform documents (Koch, 1996). Moreover, the agency responsible for funding most science education research and curriculum development in the USA, the National Science Foundation, has appropriated the STS acronym to mean "science and technology studies" (Hackett, 2000). While STS continues to have a strong minority presence in higher education, its influence on pre-college science courses in the USA is minimal but pervasive. One exception to this trend is the STS project SEPUP (Science Education for Public Understanding Project; Thier & Nagle, 1994). SEPUP has recently produced two substantial STS textbooks for grades 9-11, *Issues, Evidence and You* and *Science and Sustainability*.

One positive aspect to a slogan such as STS is its ability to garner the allegiance of a fairly diverse group of people (Roberts, 1983; Ziman, 1994). Given this diversity, however, there can be no agreement on the precise meaning of STS, as there is on the meaning of biochemistry, for instance. As a consequence, one particular STS project developed in a country can define STS science for educators of that country. Criticism of STS in that country can actually turn out to be a critique of a particular type of STS project, a type that other STS educators may find wanting as well. In one critique of STS, for example, Edgar Jenkins (1994) based his evidence largely on one project in the USA. In another critique, Jenkins (2000) characterised STS courses as supporting and enriching conventional science courses. He concluded, "something more radical than STS programmes or other attempts to 'humanize' school science is needed" (p. 220). His arguments are valid but not entirely sound, because they rest on a certain type of "add-on" STS project (e.g. *Science and Technology in Society, SATIS*; Hunt, 1988) and tend to ignore other projects whose radical materials have been publically banned from some school systems (e.g. *Logical Reasoning in Science & Technology*; Aikenhead, 2000). (The criticism by Jenkins may also seem out of synchrony with political realities, a topic for Chapter 6.) It is refreshing, however, to hear Jenkins' voice in a forum where STS projects are usually criticised and rejected for being too radical (e.g. Harding & Hare, 2000).

One way to ameliorate the problem of stereotyping STS is to systematically describe the multiple meanings it has. Guided by Fensham's (1988a) scheme that showed degrees of integration of science and technology in the context of social issues, I attempted to design a scheme that represented a spectrum of meanings found in STS courses and programs (Aikenhead, 1994b, 2000). The spectrum expresses the relative importance afforded STS content, according to two factors: (1) content structure (the proportion of STS content versus canonical science content, and the way the two are integrated), and (2) student assessment (the relative emphasis on STS content versus canonical science content). I proposed eight categories along this spectrum of STS perspectives. These categories are listed in Table 3. Category one represents the lowest priority for STS content, while category eight represents the highest priority. A dramatic change in content structure occurs between categories three and four. In category three, the content structure is defined by the discipline. In category four, it is defined by the technological or social issue itself (learning canonical science on a need-to-know basis). Interdisciplinary science begins at category five. Rather than discuss STS programs based on stereotypes as critics tend to do, we should identify various programs by the eight categories, or by some other descriptive systematic scheme. This advice extends to the most recent "science for public understanding" projects (mentioned below). Table 3 provides a language for talking about STS curricula, classroom materials, and classroom practice. Roberts (1998), Jeans (1998), and McClelland (1998), for example, used this eight-category scheme to understand experienced and novice teachers' views on curriculum change and how curriculum change might affect their classrooms.

Table 3 fits here.

All education movements are overtaken by time. In 1994, David Layton surmised that this had already happened to STS. His comments are interesting because they demonstrate Peter Fensham's (1988c) observation that changes in a curriculum occur within, and respond to, changes in social realities. Layton (1994, p. 42) stated, "a change is taking place in the overall mission of schooling [in the UK] in the direction of 'privileging the practical' (that is, relating students' experience more closely to the acquisition of practical capability in the world outside school)." Layton's expectation of the demise of STS, shared by others at the time, was based on (1) the low priority afforded technology education in many STS programs, and (2) the increasing importance of technology education for practical capability. The social realities of the 21st century, however, with crises related to genetically altered foods, the human genome project, human cloning, mad cow decease, and pharmaceuticals, for instance, have not clearly supported the ascendence of technology education, for industrial countries at least. However, sound criticism of STS over the years, such as Layton's and Jenkins', has nurtured the evolution of STS in the past, and will continue to refocus the STS movement in the future.

In Retrospect

One general theme found in the emergence and evolution of STS in school science was the way in which cultural contexts make a difference to proposals to change the status quo. For example, Peter Fensham, David Layton, and Dennis Cheek among others have consistently advanced the subculture of technology education for STS, while Roger Cross and others have consistently advanced the subculture of ethics (e.g. Cross, 1997; Cross & Price, 1992, 1999).

These and many other subcultures within academe and within educational institutions worldwide will continue to influence school science in the future.

Slogans come and go as social realities change. Nevertheless, in every era or in different political settings, it is essential to use a slogan to rally support for fundamental changes to school science (Roberts, 1983). For instance, the slogan "science-technology-society-environment" galvanised a diverse cluster of provincial ministries of education into collaborating on Canada's first national framework for a science curriculum (Aikenhead, 2000). This document has already motivated curriculum revisions in some provinces and guided the production of new science textbooks (e.g. Doug Roberts, Senior Program Consultant, *SciencePowerT* series for grades 7-10, from McGraw-Hill Ryerson). "Science-Technology-Citizenship" is a slogan in Norway where the culture tends to accentuate students' relationships with nature and with national citizenship (Royal Ministry of Church, Education & Research, 1995). Innovative Norwegian projects dedicated to teaching school science for an informed citizenry have been completed (Knain, 1999; Kolstø, 2000; Ødegaard, 2001; Sjøberg, 1997). Frequently today we read the slogans "Science for All" (Fensham, 1985), "Science for Public Understanding" (Eijkelhof & Kapteijn, 2000; Fensham & Harlen, 1999; Jenkins, 1999; Millar, 1996, 2000), "Citizen Science" (Cross, Zatsepin & Gavrilenko, 2000; Irwin, 1995), "Functional Scientific Literacy" (Ryder, 2001), or variations thereof. Which slogan will the next generation of innovative science educators adopt?

The Future

Based on the past history of STS in science education, we can anticipate that several slogans will continue to garner support for changing school science. We can also anticipate that these slogans will change over time: as innovators develop their own understanding of their field, as innovators adjust to changes in their local culture, as innovators distance themselves from stereotype perceptions of past slogans, and as innovators need to be seen doing something different. In short: STS, a rose by any other name ... .

This chapter has sought to sketch the complexity of subcultures, allegiances, self-interests, and concepts associated with the emergence, evolution, and reformulation of STS science in schools. What underlies this complexity? STS educators seem to coalesce around diverse interests and goals. This paradox begs an explanation. STS educators are similar in wanting radical changes to school science (though not radical enough for some critics), changes captured by such vague terms as humanistic, relevant, or student-centred. What coalescent force draws these science educators into the STS movement?

Throughout the past 50 years, science educators have unsuccessfully wrestled with the same dilemma: how do we prepare students to be informed and active citizens, and at the same time, how do we prepare future scientists, engineers, and medical practitioners? Some philosophers of education, such as Kieran Egan (1996), conceptualize the dilemma as two irreconcilable voices competing for the curriculum (two profoundly fundamental ideas about education). One voice, a voice of pragmatism with a lineage of thought from Jean-Jacques Rousseau, to John Dewey, to Jean Piaget, to Ros Driver, speaks to encouraging the development of each student's individual potential. For example, learning how to learn and being able to use what one has learned (for social reconstruction, perhaps) are considered superior to amassing academic knowledge. This pragmatic voice defines the nucleus of STS educators' professional values, I submit; a solution to the paradox above.

However, a second voice analysed by Egan speaks to privileging Plato and the "truth about reality." For example, students will amass "knowledge that will ensure that their thinking conforms with what is real and true about the world" (p. 8). An academic curriculum can develop a "privileged, rational view of reality" (p. 13). Egan pointed out that any proposal for changing the school curriculum must resolve this theoretical incompatibility, otherwise the innovation will be futile. But by including both ideas within a curriculum, we continue the dysfunctionality that causes fundamental tensions and failures in schools today, Egan argues.

Some STS educators have attempted to resolve the incompatibility. Drawing on empirical evidence, some have claimed that *not* transmitting Platonic-truth knowledge to students does not necessarily undermine the pre-professional training goal of science education, given the current structure of university science and engineering programs (Aikenhead, 1994a; Fensham, 1996b; Tobias, 1990; Yager & Krajcik, 1989); that is, talented students with an interest in the sciences can succeed in university science-related programs irrespective of the students' experiences in school science. On the other side of the coin, the consequences of transmitting a Platonic-truth science curriculum turns out to have an overall negative impact on talented students with an interest in science (Bondi, 1985; Majumdar et al., 1991; Oxford University, 1989); that is, many talented high school students switch out of science upon graduating. Therefore, on philosophical grounds, the privileged voice of Platonic truth can either be ignored by, or be a nuance within, a science curriculum dominated by pragmatic thought (Aikenhead, 1980). Philosophical grounds, however, are not the social and political realities inhabited by most science educators. Marginalising Platonic truth is a political act.

My conclusion is this: changing the status quo science curriculum cannot be achieved by STS-like curriculum innovations based on rational philosophical grounds alone (i.e. successfully arguing with empirical evidence that a pragmatic curriculum is superior to a privileged curriculum). Changing the status quo also requires political interventions based on creative, irrational, power-brokering politics (Aikenhead, 2002; and Chapter 6 in this volume). To ignore the politics, to shrug them off, to leave them to others, to avoid them in whatever manner, is to make a pact with futility, no matter what slogan we live by. Yet again, Peter Fensham (1988d, 1992, 1998a, 1998b) has helped lead the way.

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Table 1. Yearbooks and Special Issues of Journals Dedicated to STS

Publication	Reference
NSTA yearbook, *Science Technology Society*	Bybee, 1985
AETS yearbook, *Science, Technology and Society: Resources for Science Educators*	James, 1985
Special STS issue, *International Journal of Science Education*	Holman, 1988
Two special STS issues, *Theory into Practice*	Gilliom, Helgeson & Zuga, 1991, 1992
ICASE yearbook, *The Status of Science-Technology-Society Reform Efforts around the World*	Yager, 1992
Special issue, *Melbourne Studies in Education*	Cross & Fensham, 2000

Table 2. Key STS Science Education Books

Publication	Reference
Teaching and Learning about Science and Society	Ziman, 1980
Thinking Constructively about Science, Technology, and Society Education	Cheek, 1992
Teaching Science, Technology and Society	Solomon, 1993
STS Education: International Perspectives on Reform	Solomon & Aikenhead, 1994
Science/Technology/Society as Reform in Science Education	Yager, 1996b
Science, Technology, and Society: A Sourcebook on Research and Practice	Kumar & Chubin, 2000

Table 3. Categories of STS in School Science

1.	Motivation by STS content
2.	Casual infusion of STS content
3.	Purposeful infusion of STS content
4.	Singular discipline through STS content
5.	Science through STS content
6.	Science along with STS content
7.	Infusion of science into STS content
8.	STS content